Upper and Lower Strands in a Straight Run

Hazard
Return rollers

Possible Consequences
Impact with rollers
Crushed by falling rollers

Protective Measures
(Throughway under conveyor more than 2.5 m)

Retaining device for return rollers, (figure 2-26) according to risk analysis results. It is possible to reduce the risk with a preventative maintenance program, which should be taken into account when doing the risk analysis.

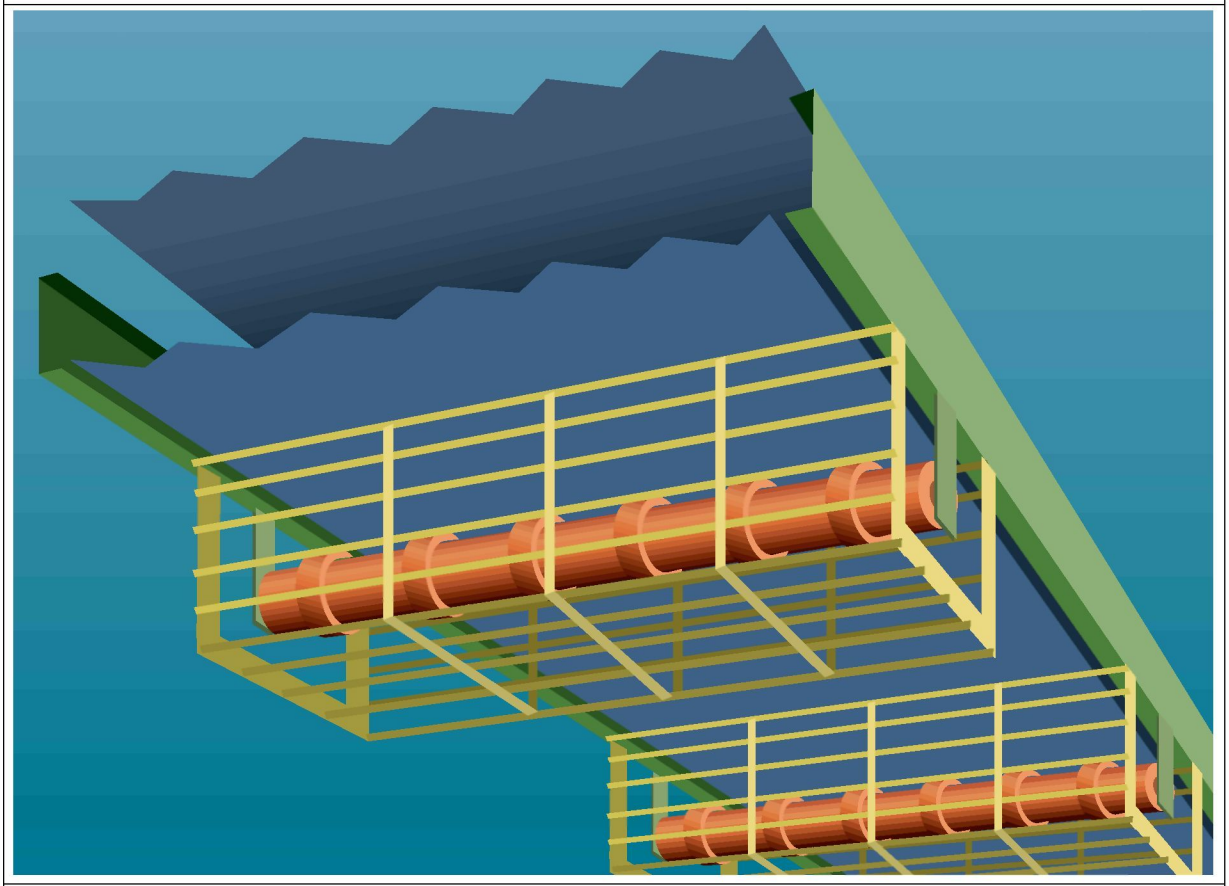


FIGURE 2-26 RETURN ROLLER RETAINING DEVICE

Upper and Lower Strands in a Straight Run

Hazard
Bottom strand scrapers

Possible Consequences
Trapping and crushing
Abrasions from the belt

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

In accordance with risk analysis results the scraper protection device may be combined with the drum protection device (figure 2-27)

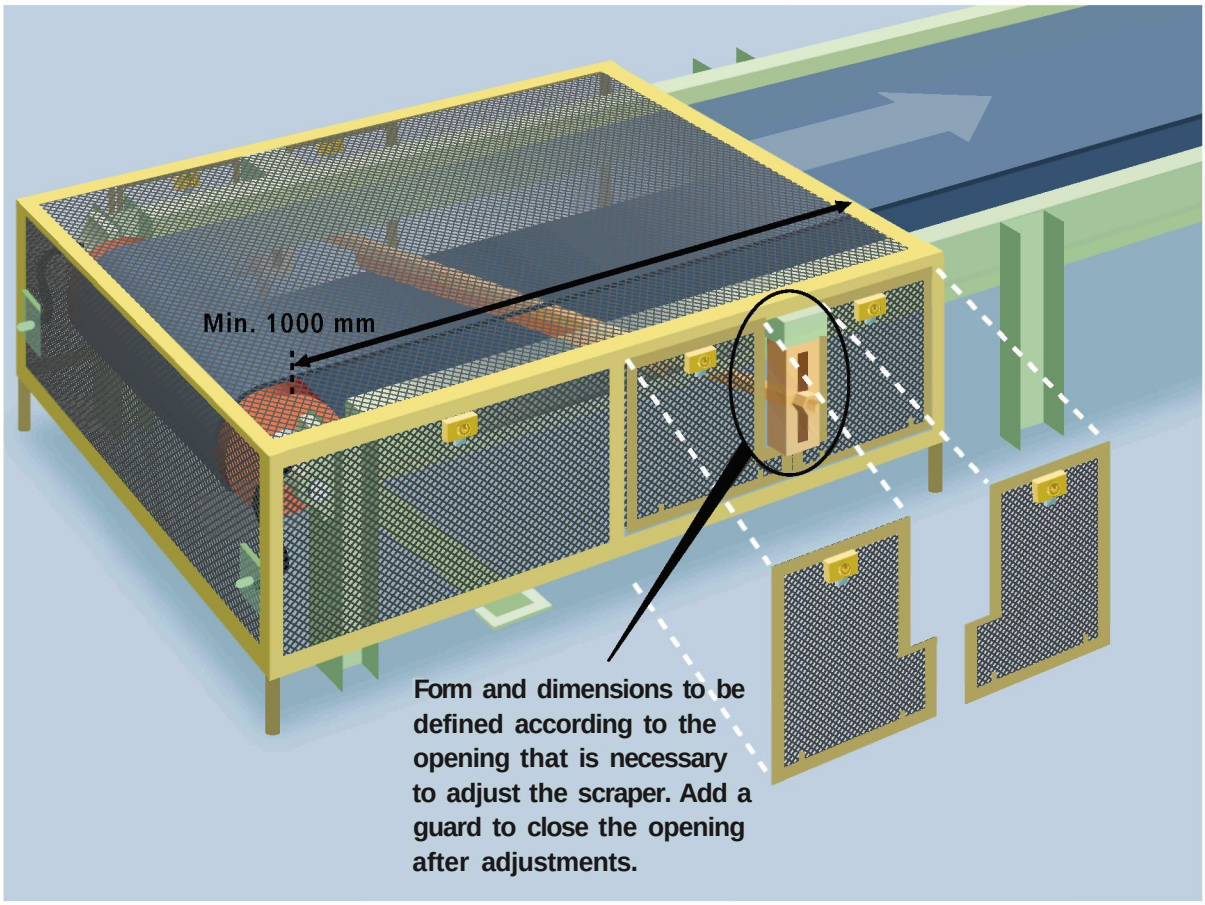

Min. 1000 mm
Form and dimensions to be defined according to the opening that is necessary to adjust the scraper. Add a guard to close the opening after adjustments.

FIGURE 2-27 SURROUNDING BARRIER GUARD FOR DRUM AND SCRAPER (PARTIAL CAGE)

2.6.4 Curved Zone

Hazards
In-running nip between the belt and rollers in the curved zone

Possible Consequences
Drawing-in

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)
Surrounding in-running nip or separation barrier guard (figures 2-28 and 2-29)

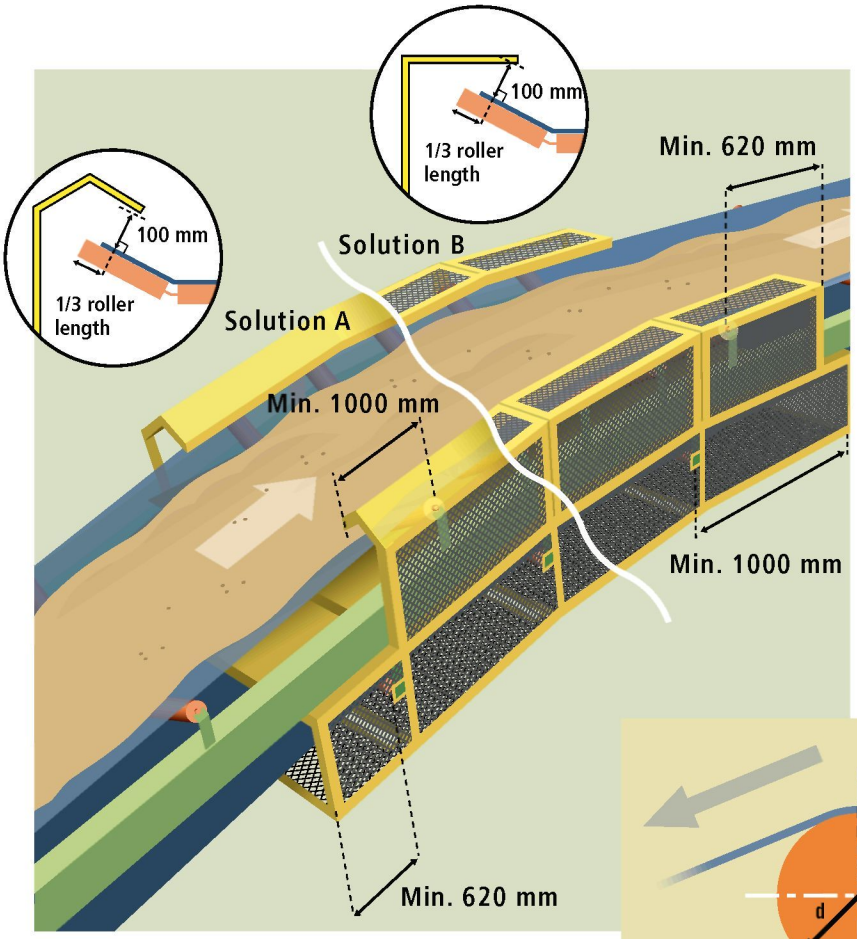


FIGURE 2-28 SURROUNDING FIXED GUARDS FOR CURVED ZONE

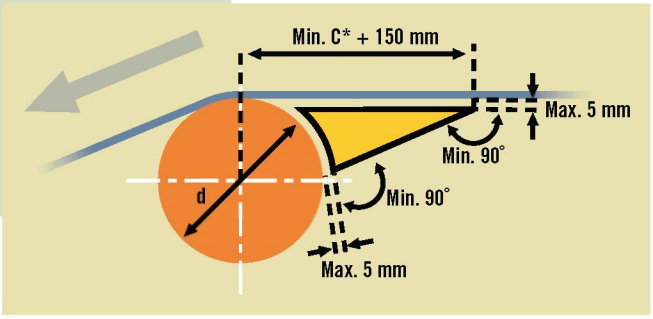


FIGURE 2-29 CURVED ZONE IN-RUNNING NIP GUARD
*SEE TABLE 2-3 FOR C DIMENSION

Note: Belt edge tension is greater in the curved zones.

2.6.5 Transition Zone

Hazard
In-running nips between the upper strand and the load carrying rollers in the transition zone

Possible Consequences
Drawing-in

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)
Surrounding or in-running nip (figure 2-30)

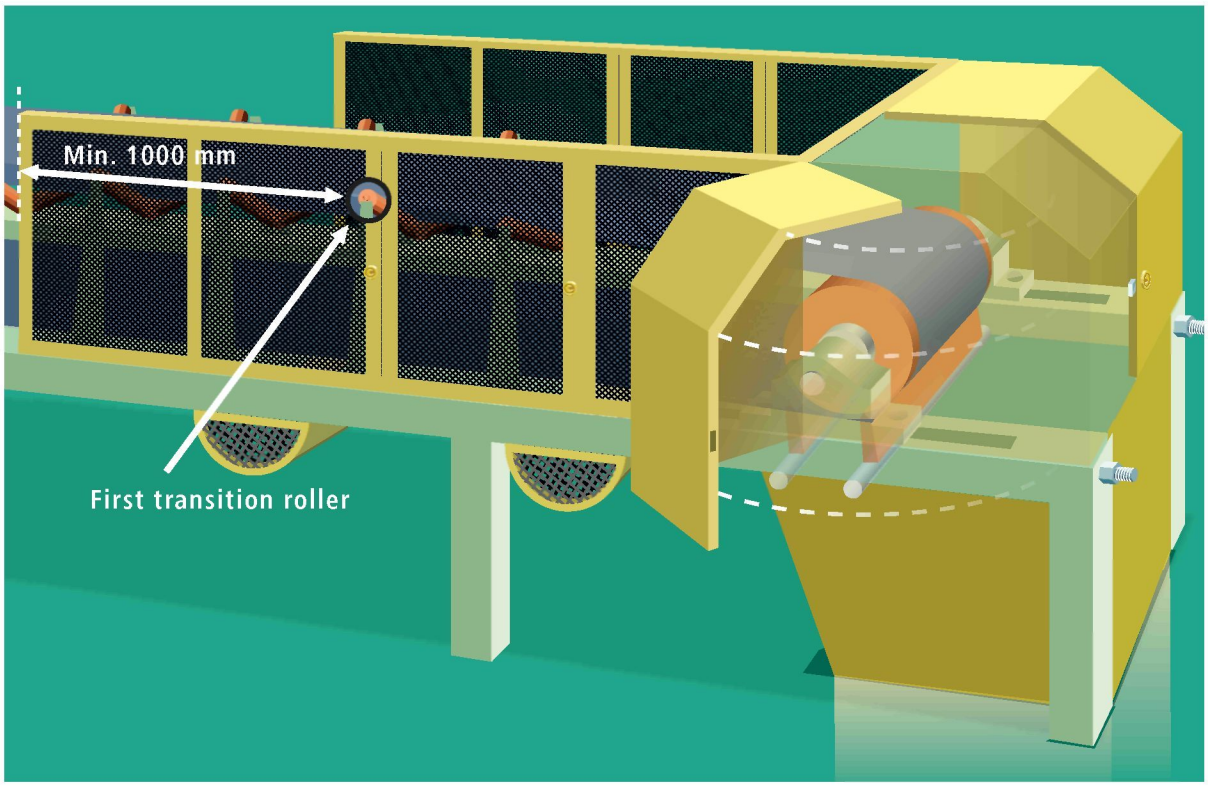


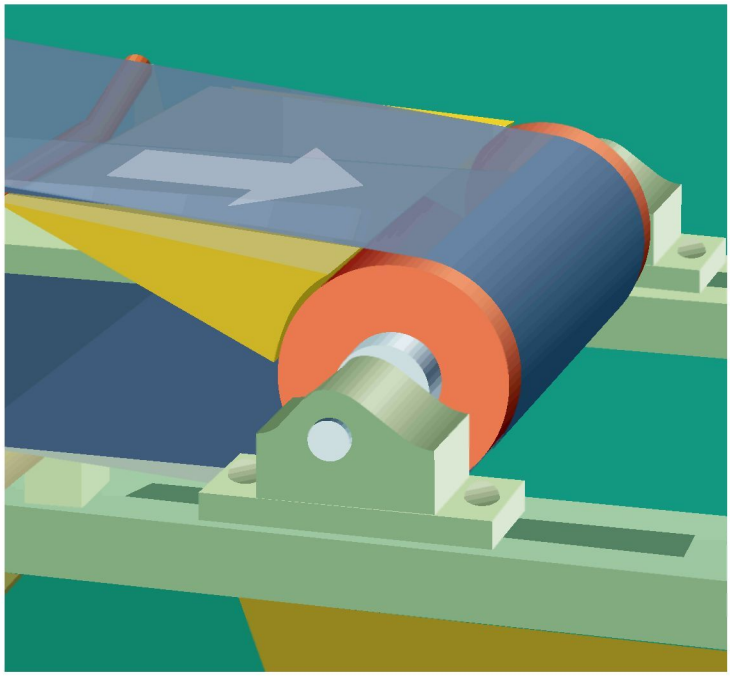
FIGURE 2-30 PROTECTORS FOR HEAD DRUM AND TRANSITION ZONE
(TO DETERMINE LATERAL SCREEN HEIGHT, SEE TABLE 2-2)

2.6.6 Drums

Hazards
In-running nips between belt and drums **(1 of 2)**

Possible Consequences
Drawing-in

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)
Surrounding in-running nip or barrier guards (figures 2-30 to 2-33)



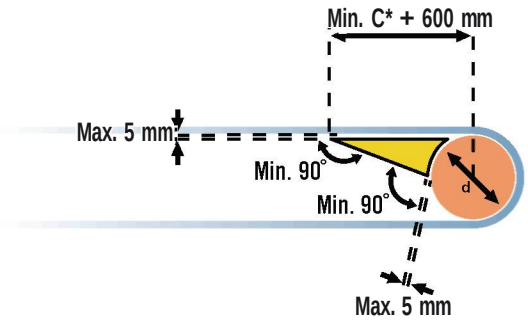


FIGURE 2-31 IN-RUNNING NIP GUARD FOR DRUM
***SEE TABLE 2-3 FOR C DIMENSIONS**

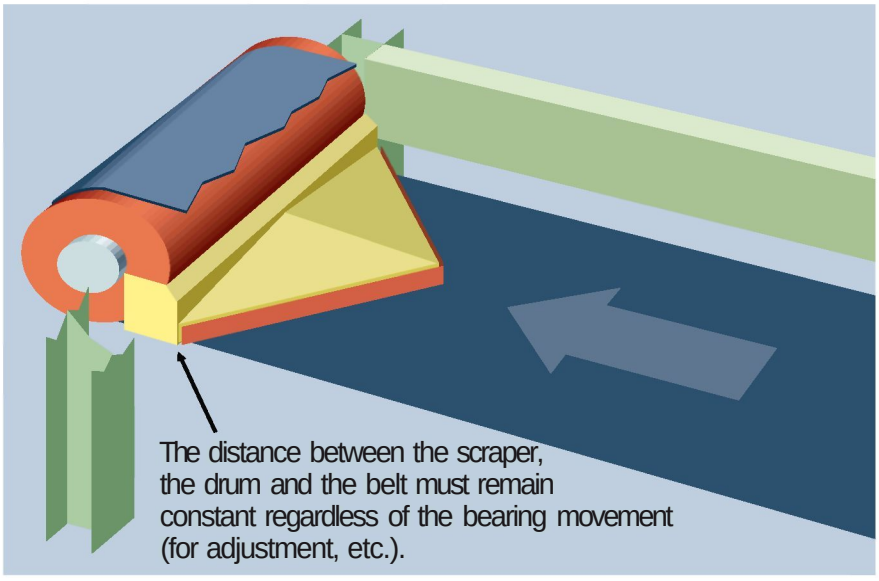

The distance between the scraper, the drum and the belt must remain constant regardless of the bearing movement (for adjustment, etc.).

FIGURE 2-32 SCRAPER SERVING AS AN IN-RUNNING NIP GUARD

Drums

Hazard
In-running nips between belt and drums **(2 of 2)**

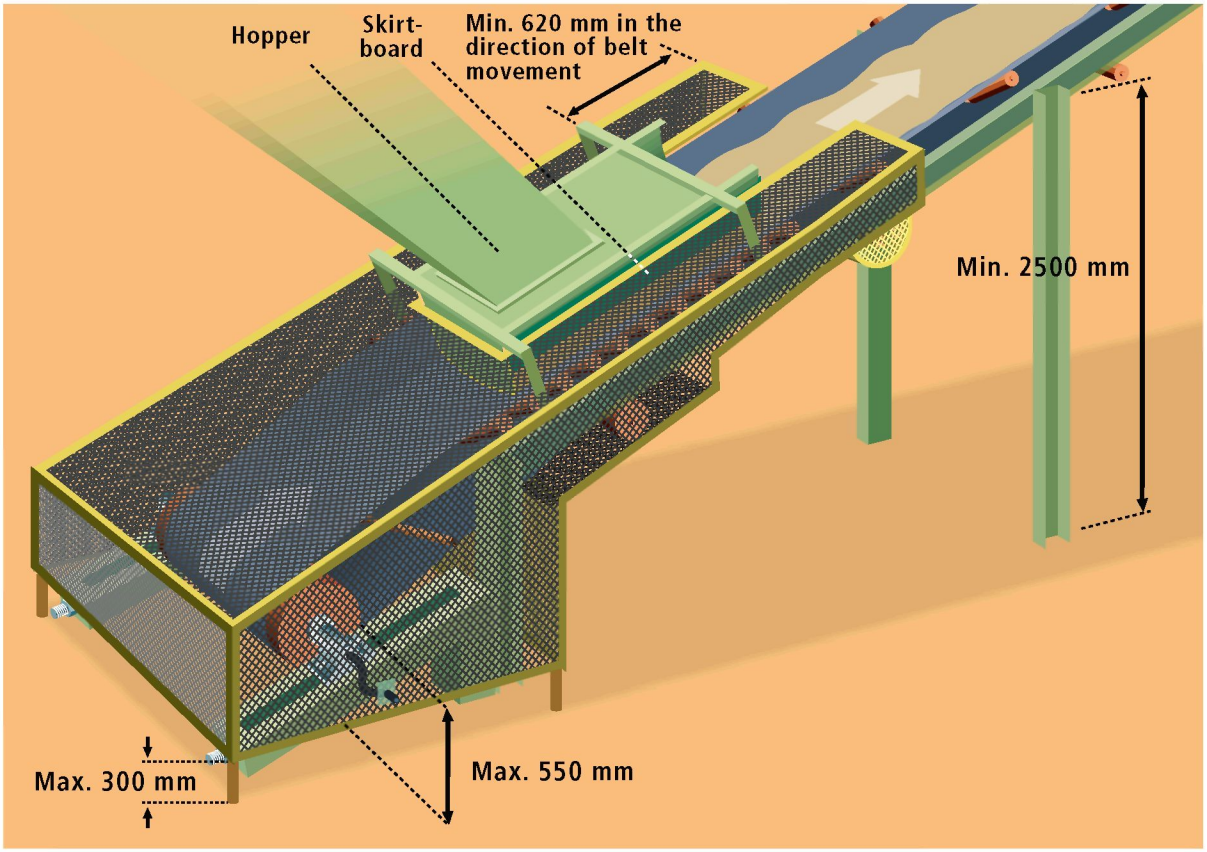


FIGURE 2-33 SURROUNDING FIXED GUARD FOR TAIL DRUM

Note: If it's not possible to comply with the 550 mm minimum distance between the in-running nip and the bottom edge of the surrounding fixed guard, the opening for housekeeping should be in accordance with table 2-1.

Drums

Hazard
Take-up system

Possible Consequences
Crushed by falling weights
Drawn in at pinch points

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

Surrounding or barrier guards (figures 2-33 and 2-34)

If the weight is always more than 2.5 m from the floor or working platform

Deterrent device (guardrail) to prevent access under the weight

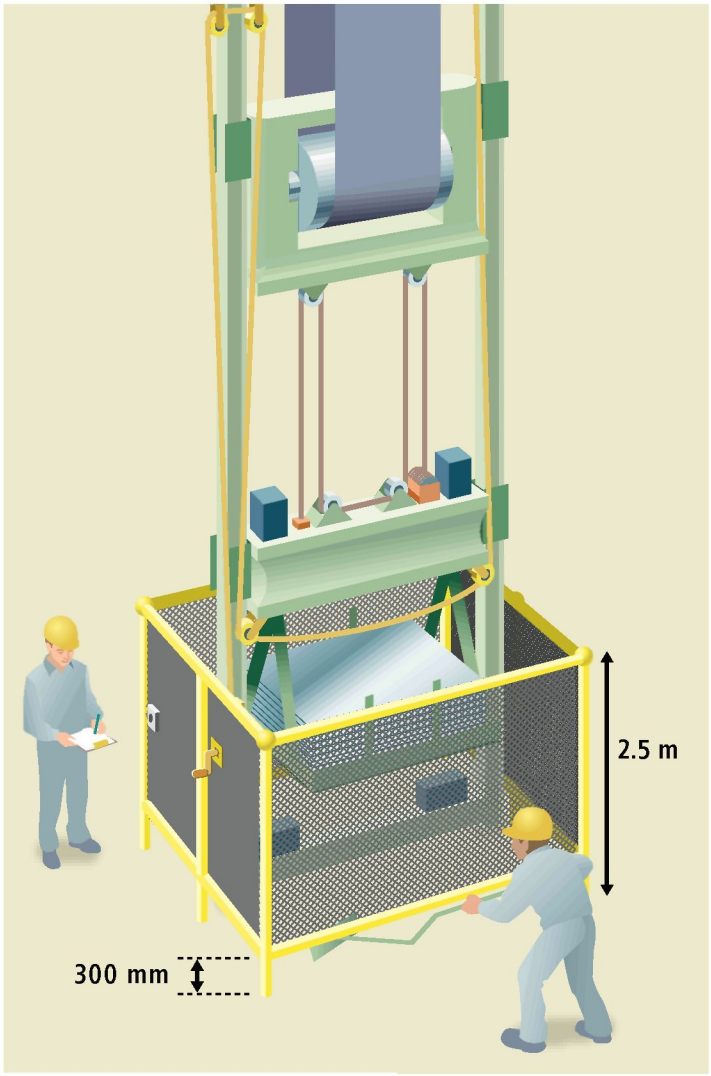


FIGURE 2-34 BARRIER GUARD FOR GRAVITY-TYPE TENSIONER

Note: For gravity-type tensioning devices, the height of the barrier preventing access under the counterweight must be 2,500 mm.
Tensioner drums (head or tail) must also be protected.

Drums

Hazard
Junction between two conveyors

Possible Consequences
Drawing-in and trapping, if the gap is greater than 5 mm

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)
Fixed guard (plate) or free-wheeling pop-up roller (figures 2-35 and 2-36)

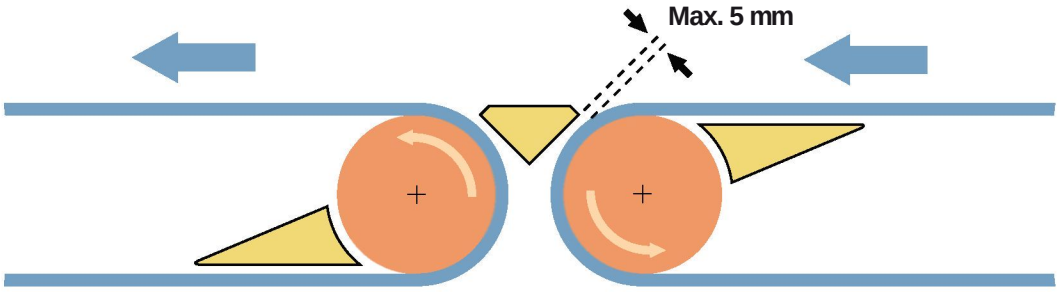


FIGURE 2-35 FIXED GUARD AT CONVEYOR BELT JUNCTION

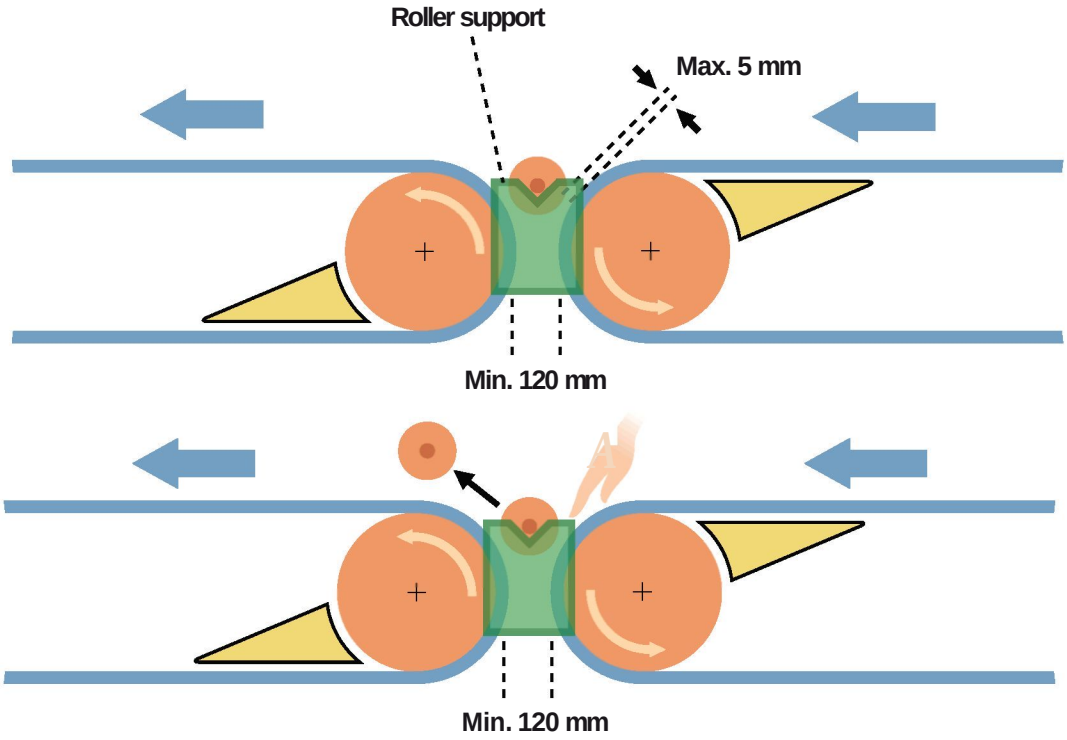


FIGURE 2-36 POP-UP ROLLER AT CONVEYOR BELT JUNCTION

2.6.7 Moving Loads

Hazard
Skirtboards
Individual moving loads

Possible Consequences
Trapped between belt and skirtboard or between the load and the skirtboard

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

Workstation
Limit the gap between the skirtboard and belt to a maximum of 5 mm
Remove the skirtboard
Design a surrounding fixed guard if need determined in risk analysis

Other Areas
Risk analysis

Note: When doing the risk analysis, take into account the possibility of falling loads with the removal of the skirtboard.

Moving Loads

Hazard
Individual loads and fixed obstacles not part of the conveyor, e.g., post, wall, tunnel entrance, enclave, associated fixed equipment (detectors), etc., large bulk sized loads (e.g., boulders)

Possible Consequences
Crushed between loads and fixed objects
Shearing
Impact with loads or other objects

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

Fixed guard or deterrent device (figure 2-37) in accordance with risk analysis results, in respecting the safe distances between loads and obstacles (following are minimum distances for different situations):

If the entire body can be drawn in: 500 mm, minimum
If arms can be drawn in: 120 mm, minimum
If legs can be drawn in: 180 mm, minimum

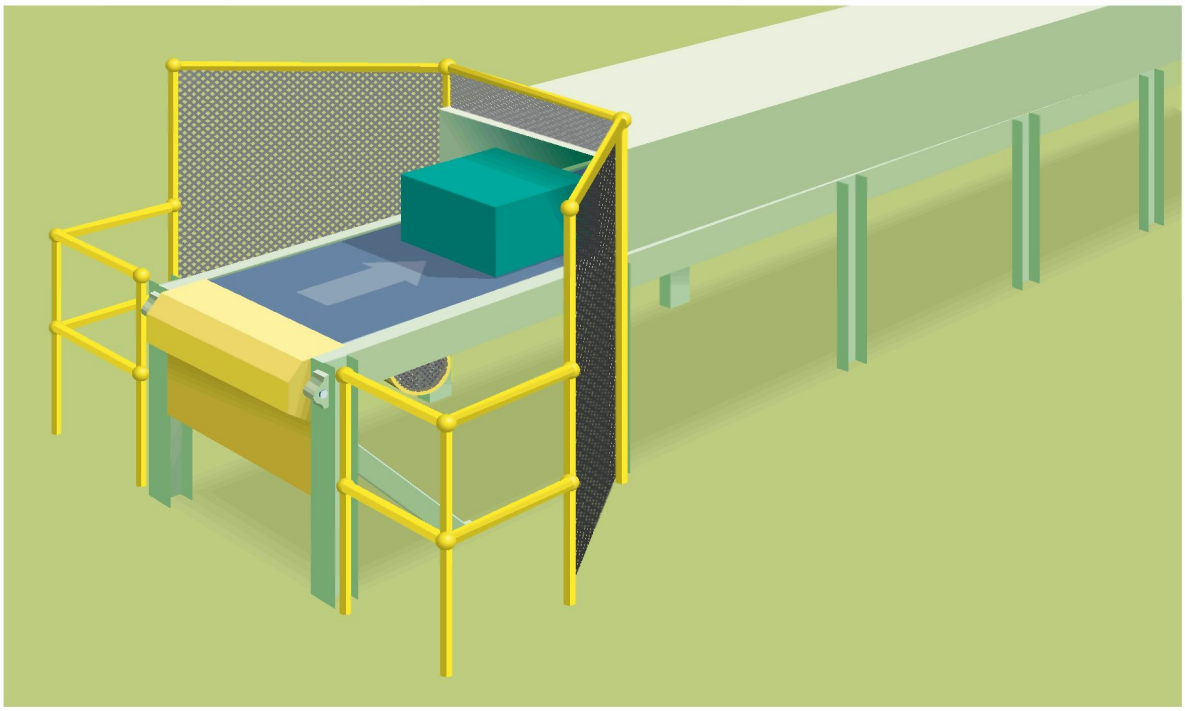


FIGURE 2-37 TYPICAL PROTECTIVE MEASURES AGAINST HAZARDS ASSOCIATED WITH INDIVIDUAL LOADS AND FIXED OBSTACLES

Note: The objective is to keep the body, arms and legs away from the crushing area.

The type of guard and its dimensions will depend upon body part at risk of being trapped and the weight of the load, as determined in the risk analysis.

The guard must not in itself create a drawing-in or trapping area.

Moving Loads

Hazard
Load and load carrying rollers exceeding belt width

Possible Consequences
Trapping
Crushing

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

Workstation
Fixed barrier guard (separation type or plates between rollers) (figure 2-38)

Other Areas
Fixed barrier guard (separation type or plates between rollers) or deterrent device

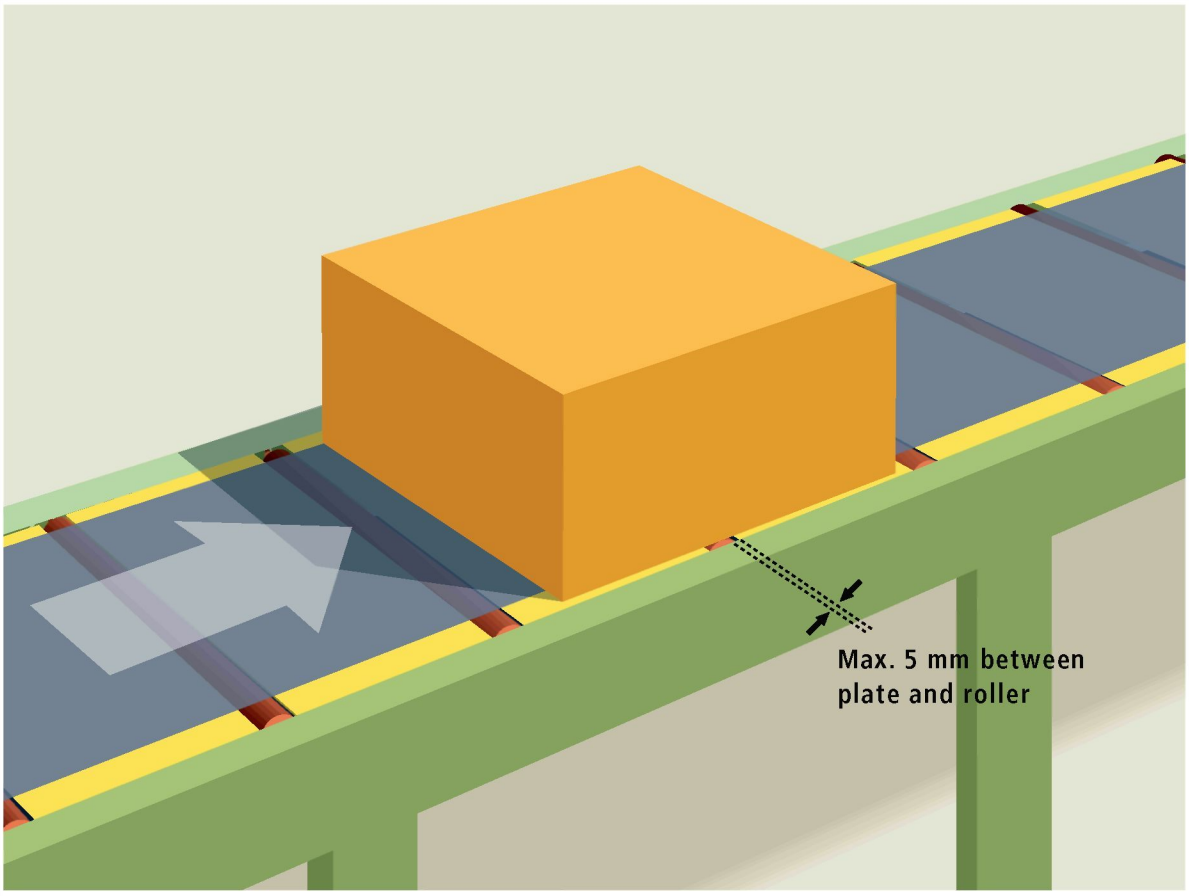


FIGURE 2-38 TYPICAL GUARD FOR INDIVIDUAL LOADS AND ROLLERS EXCEEDING BELT WIDTH

Moving Loads

Hazard
Loads falling from the belt

Possible Consequences
Impact with moving loads
Crushed by falling loads

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

Protection plate, mesh, netting, or guiding rail to maintain individual loads on the conveyor and prevent them from falling off, in accordance with risk analysis results, (figure 2-39)

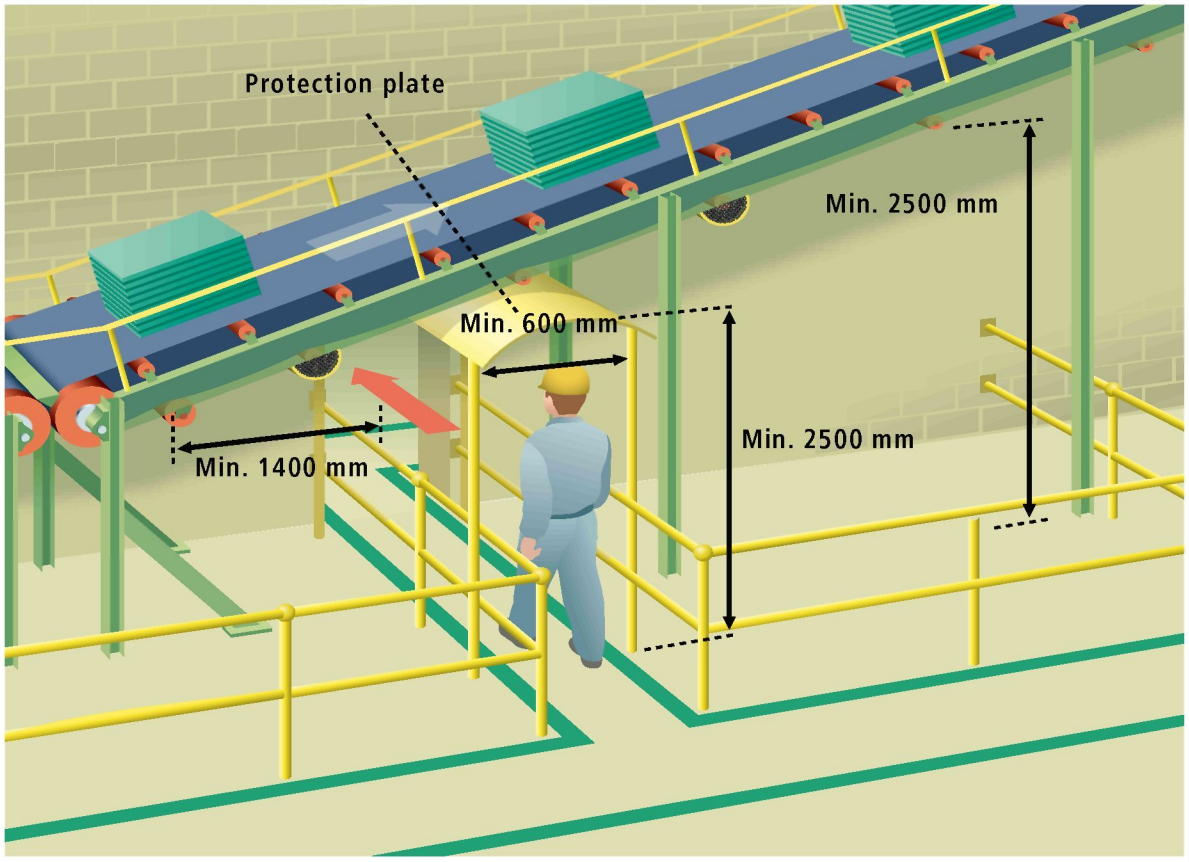


FIGURE 2-39 TYPICAL PROTECTIVE DEVICES FOR THROUGHWAYS

2.6.8 Moving Sub-Assemblies

Hazard
Pushers; bumpers; ejectors; sorters

Possible Consequences
Crushing and shearing

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)
Surrounding fixed or barrier guards (figure 2-40)

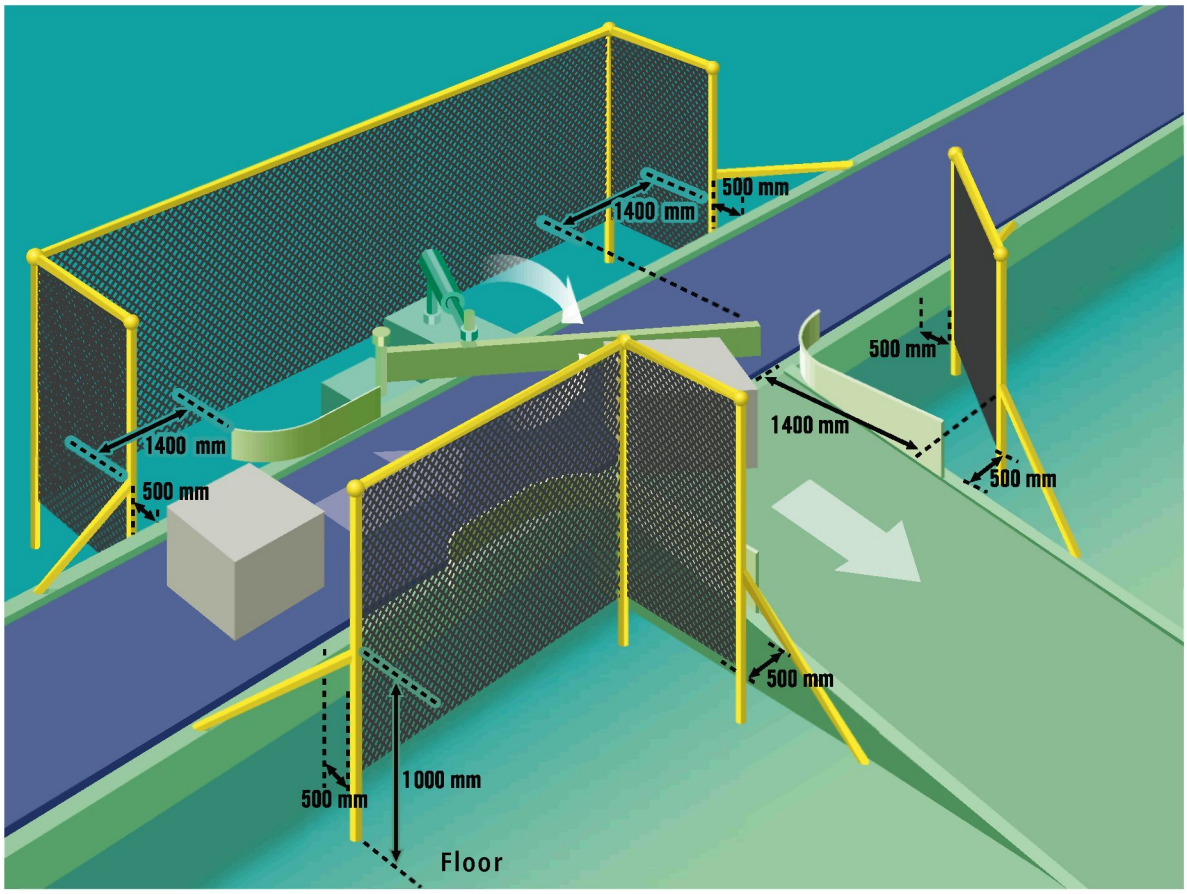


FIGURE 2-40 TYPICAL BARRIERS FOR EJECTORS

Note: Leave a safe distance between the load and the guard so as not to create a trapping hazard. Minimum distances are:

If the entire body can be drawn in: 500 mm, minimum
If arms can be drawn in: 120 mm, minimum
If legs can be drawn in: 180 mm, minimum

2.6.9 Moveable Conveyors

Hazard
Vertical and/or horizontal movement

Possible Consequences
Crushing; entanglement; trapping

Protective Measures
(If hazard is less than 2.5 m from the floor or working platform)

In accordance with risk analysis results: barrier guard, deterrent device, or ground markings or signs to indicate the conveyor's operating area (figure 2-41)

It is also possible to use electronic safety devices (surface detectors, etc.)

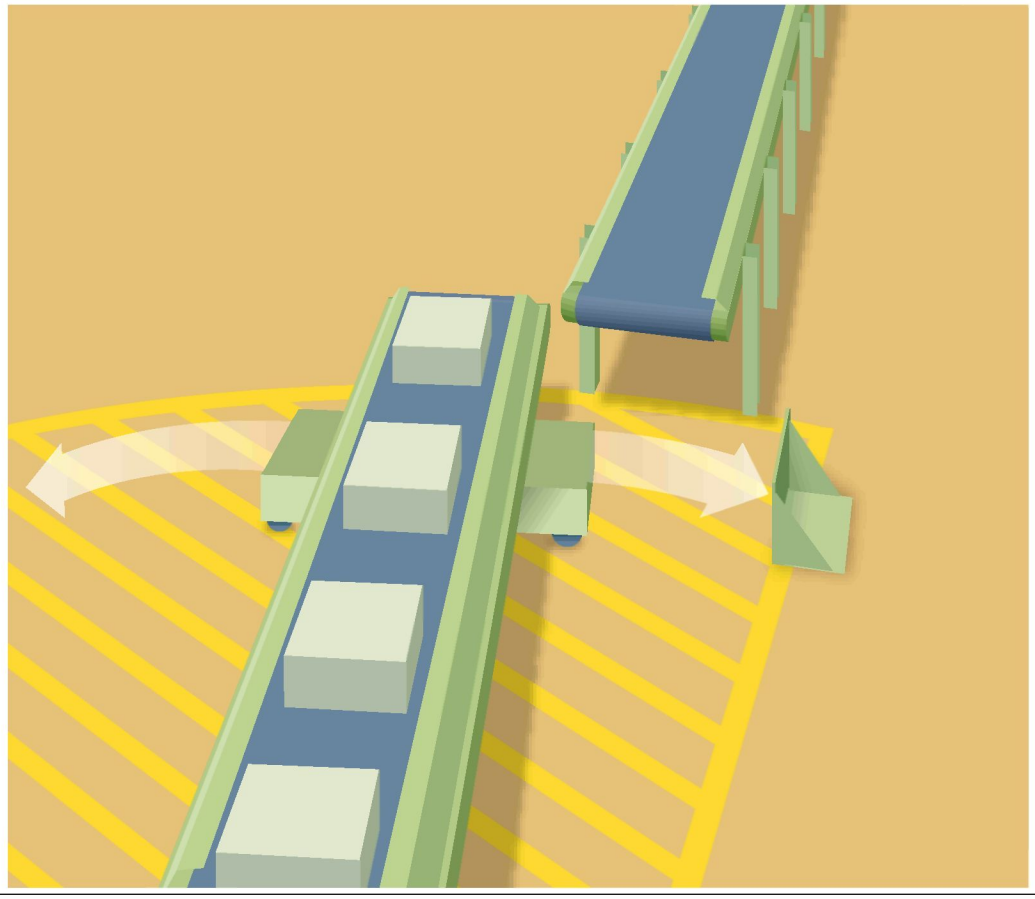


FIGURE 2-41 MOVEABLE CONVEYOR

Note: The limits of the operating area must be considered before applying protective measures.

3 Safeguards against Other Hazards

3.1 Hazards Generated by Poor Ergonomic Design

Equipment must be designed so that operators and other users need not assume constraining work postures, overexert themselves or carry out repetitive movements.

Control devices must be grouped near workstations to allow operators and other users easy access. They must be located outside danger zones so that activating them does not create hazards and workers do not have to enter the danger zones to access them. To prevent unexpected start-ups, they must be positioned and protected.[14]

Every workstation or intervention area must be provided with adequate lighting for the nature of the work being done or the nature of the work environment (section 125 of the Regulation Respecting Occupational Health and Safety).

3.2 Heat-Related Hazards

Where conveyed products or any part of the equipment may cause burns, take the following precautions:

- Prevent contact with conveyed loads and hot (or cold) surfaces by the use of screens, fixed surrounding or barrier guards
- Reduce the temperature of hot surfaces

3.3 Electrical Hazards

Conveyor electrical equipment must conform to the *Québec Electrical Code*. Such equipment includes: materials, accessories, devices, appliances, fasteners and other equipment used in the electrical power supply of a conveyor or in connection with a conveyor, these include power disconnect devices.

In mines, electrical equipment must also conform to the CAN/CSA Standard M421-93,[15] particularly those sections dealing with conveyors.

3.4 Fire and Explosion Hazards

The use of conveyors can in itself be a fire and explosion hazard. These hazards can be caused by the use of the conveyor itself or by the load the conveyor is carrying (for example, combustible particles). These hazards may be amplified by tunnels or the stack effect. Preventative measures to implement are described in division VIII of the Regulation Respecting Occupational Health and Safety and in section 374 of the Regulation Respecting Occupational Health and Safety in Mines.

In underground mines, fire and explosion hazards related to belts can have particularly serious consequences. Belts must conform to CAN/CSA Standard M422-M87.[16]

4 Safeguards against Control System Failures or Malfunctions

4.1 Start-Up

The start-up of equipment must require a voluntary action. Equipment start-up must be prevented in the following situations.[14]

- The closing of a guard
- The actuation of an operation mode selector
- The resetting of an emergency stop device
- The resetting of a thermal protection device

In conveyors designed to supply loads to other conveyors, start-up of the supply conveyor must be linked with the receiving conveyors, using appropriate interlocking devices. These devices must control and ensure proper sequential start-up and prevent conveyor loading when not in use or when fully loaded.[7]

For automatic or remote-control start-up conveyors, as well as conveyors for which the operator or the user cannot see the entire conveyor, a visual or audible warning device shall announce the starting of the conveyor (sections 191 of the Regulation Respecting Occupational Health and Safety and 373.6 of the Regulation Respecting Occupational Health and Safety in Mines).

To prevent unexpected start-ups, replace two-stable position (toggle) switches (start-stop) with self-powered (contacts maintained by power) or single-stable position (stable at the unenergized condition) control devices. These switches will bring the controls to an off-circuit mode (open contacts) should there be a power outage or conveyor failure.

4.2 Regular Stop

There must be a device or a method accessible to the operator and other users whereby equipment operations can be interrupted safely, while guaranteeing that the equipment cannot be unexpectedly restarted.

An all-stop switch is not designed to put an end to a recurring dangerous situation; this is the role of an emergency stop switch. A stop command must have priority over a start command.

4.3 Emergency Stop

According to section 270 of the Regulation Respecting Occupational Health and Safety, *the emergency stop device of a conveyor to which workers have access comprises several control devices located at loading and unloading piers as well as at other points along the conveyor's itinerary. In addition, these devices have the following features:*

(1) *they are easily visible;*

(2) *one single action activates them;*

(3) *they are clearly identified.*

An emergency stop device should also be activated by a positive action and be forced to break contact type device (symbol illustrated in figure 2-42).

FIGURE 2-42 STANDARD SYMBOL DESIGNATING FORCED TO BREAK CONTACT DEVICES

Emergency stop devices must be installed at a height between 0.6 m and 1.7 m from the floor and must include the following:[7]

- One or more push-button switches installed in such a manner that at least one is accessible within a 10 m distance from any equipment access point;
- One or more emergency stop pull cords along the full conveyor length (compulsory measure for mines where workers may have access to conveyors in operation [section 373.5 of the Regulation Respecting Occupational Health and Safety in Mines]);
- A conveyor power disconnect device, if the distance to the disconnect device is less than10 m from any conveyor access point.

An emergency stop device must allow equipment to shut down in the best possible manner, that is, by slowing down moving parts at an optimal rate by:

- An immediate interruption of power to the motors;
- A controlled stop — motors remain energized to bring the equipment to a progressive stop and power is interrupted once the equipment has come to a halt.

The resetting of the emergency stop device must not, by itself, cause the start-up of the machine, unless the conveyor is a slow moving type and workers can access it safely (section 270 of the Regulation Respecting Occupational Health and Safety). Moreover, start-up must be confirmed by a distinct and deliberate manual action (manual resetting).

The emergency stop command must have priority over all other commands and cannot be allowed to create dangerous situations such as load spillage. The conveyor emergency stop device must also stop any downstream or upstream conveyors if their continued operation constitutes a safety hazard for workers (section 193 of the Regulation Respecting Occupational Health and Safety). An emergency stop device must not be used to bring the conveyor to an all-stop state. The emergency stop must not be used as a regular stop.

Remember that the installation of an emergency stop device does not replace appropriate protective devices. As well, emergency stop devices must not replace equipment lockout procedures during maintenance requiring access to danger zones.

For more information on the operation of emergency stop devices, consult ISO Standard 13850[17] and NF EN 60947-5-5.[18]

4.4 Emergency Stop Pull Cords

According to section 373.5 of the Regulation Respecting Occupational Health and Safety in Mines, all conveyors must *be equipped, where the workers may access a conveyor while it is in operation, with an emergency shut-down device along its full length between the head pulley and the return pulley* (tail pulley)*; (…).* Therefore, for all mines, the emergency shut-down device must take the form of a cable spanning the full length of the conveyor.

In other workplaces, an emergency stop cable may not be necessary where another shut-down device has been installed in accordance with section 270 of the Regulation Respecting Occupational Health and Safety.

A sheathed metal strand cable shut-down device must function as an emergency stop switch whatever direction the cable is pulled in or when it is broken. A spring failure must also create an emergency stop.

A horizontal force of less than 125 N must be all that is needed to activate an emergency stop cable, when applied midway between two support rings and perpendicularly to the cable. The lateral movement of the cable (between the position while at rest and the activation point) must not exceed 300 mm.[7]

The cable must be able to resist a tension force 10 times greater than the tension required to activate the emergency shut-down switch, when applied perpendicularly to the cable.[18]

The cable must move freely within its supports, particularly at bends. Cables must not be twisted nor suffer the risk of being twisted during use.

If the belt width is equal to or less than 800 mm, a single central cable may be used above the belt.[19]

Maximum cable length and other characteristics must conform to the supplier's recommendations (for support rings and pulley protection, freeze-up prevention, variations in length due to temperature changes, etc.).

Sensitive cable devices may be used where activation of the switch is done by pressure, compression, torsion or tension applied to the cable. This method is best suited to complex cable runs and to dusty or heavy vibration environments.

5 Safeguards against Maintenance Hazards

Sécurité des convoyeurs à courroie : guide du concepteur (*A Designer's Guide to Conveyor Belt Safety)* provides additional information on this subject. It discusses the incidence of the design factor on conveyor safety, explains conveyor failure and diagnostics, and suggests solutions for use during the problem-solving process. A fault tree helps establish the relationship between failures and accidents.

5.1 General Principles

Equipment must be designed in such a way that maintenance (adjustments, greasing, cleaning, unjamming, unclogging, etc.) can be accomplished away from danger zones. Therefore, all adjustment and grease points must be accessible without having to remove guards or other protective devices.

When it is necessary to open or remove guards, or even to neutralize protective devices in order to carry out a maintenance procedure, safeguards must be implemented to ensure worker safety in the areas transformed into danger zones. These measures must conform to sections 185 and 186 of the Regulations Respecting Occupational Health and Safety.

According to section 185 of the Regulation Respecting Occupational Health and Safety: *Subject to the provisions of section 186, before undertaking any maintenance, repair or unjamming work in a machine's danger zone, the following safety precautions shall be taken:*

(1) *turn the machine's power supply switch to the off position;*

(2) *bring the machine to a complete stop;*

(3) *each person exposed to danger locks off all the machine's sources of energy in order to avoid any accidental start-up of the machine for the duration of the work.*

5.2 Lockout Procedures

The goal of lockout procedures is to allow workers to carry out their tasks (maintenance, repairs, cleaning, etc.) on a conveyor and its accessories (bumpers, ejectors, etc.) without risk.

Lockout procedures* involve the following basics:

- Bringing the machine to a complete stop.
- Disconnecting all the machine's sources of power: electric, pneumatic, hydraulic, mechanical and thermal.
- Dissipating all accumulated energy (purging reservoirs, removing counterweights, unloading springs, etc.) and checking for absence of energy.
- Padlocking of energy disconnect devices by each worker accessing the work area.
- Double-checking to ensure that the equipment is in fact disconnected (e.g., running a start-up test).

*Consult document DD 754,[20] ANSI Standard Z244.1[21] or the CSA Standard Z460.

5.3 Safeguards for Maintenance within Operating Danger Zones

Section 186 of the Regulation Respecting Occupational Health and Safety stipulates: *When a worker must access a machine's danger zone for adjustment, unjamming, maintenance, apprenticeship or repair purposes, including for detecting abnormal operations, and to do so, he must move or remove a protector or neutralize a protective device, the machine shall only be restarted by means of a manual control or in compliance with a safety procedure specifically provided for allowing such access. This manual control or this procedure shall have the following characteristics:*

(1) *it causes any other control mode or any other procedure, as the case may be, to become inoperative;*

(2) *it only allows the operating of the dangerous parts of the machine by a control device requiring continuous action or a two-hand control device;*

(3) *it only allows the operation of these dangerous parts under enhanced security conditions, for instance, at low speed, under reduced tension, step-by-step or by separate steps.**

For these measures to produce the desired results and given the serious hazards associated with conveyors, they should incorporate the following recommendations:

- Operation control devices, including two-hand controls, should require hold-to-run input
- The operation control device used by the worker should have priority over all other control devices on the machine
- When maintenance is carried out by more than one worker, while some hazards may be reduced; those related to machine operation controls may increase – establish a clear communication procedure to ensure clear communication between workers
- Prohibit the use of remote wireless operation controls
- Control cables should be long enough to allow visual contact with the danger zone, all the while making access to the danger zone impossible

5.4 Summary of Maintenance Safeguards

Table 2-4 lists the safeguards required when carrying out most maintenance activities on conveyor belts or in proximity to conveyor belts. They should be addressed in maintenance procedures.

* The inching forward of an operation control should allow limited advance in separate steps; no further advancement of machinery should be allowed until the operator releases the control device and then actuates the controls anew.

Table 2-4 Safeguards for Maintenance Activities

Activity	Safeguards
Repairs **Changing mechanical, electrical, hydraulic or pneumatic parts on conveyors or related accessories**	Lockout conveyor or related accessory.
Belt replacement and splicing	Lockout and application of a written safety procedure. See *Sécurité des convoyeurs à courroie : guide du concepteur (A Designer's Guide to Conveyor Belt Safety)* section 4.1.1 for required tools and facilities.
Welding and cutting*	Lockout if conveyor is located under the welding area. Lockout if the closed unprotected danger zone is less than 2,500 mm from the work area.
Adjustment and fit	Authorized at all times provided adjustment points (for example: scraper, drum and take-up system adjustment) are outside the danger zone. Lockout if adjustment points are inside the danger zone. Application of stipulations in section 5.3 (drum and scraper restrictions).
Greasing and oiling (lubrication)	Authorized at all times where grease points are outside the danger zone. Lockout if grease points are inside the danger zone.
Housekeeping under and around conveyor; disposal of material recovered on the belt	Authorized at all times as long as the danger zone remains protected by a guard. Particular attention should be paid to the space under an inclined belt located less than 2.5 m from the floor (belt risk analysis). **Reminder:** A 300 mm high opening measured from the floor will help in housekeeping. Lockout if the danger zone is not protected with a guard. Apply measures in section 5.3 should the conveyor need to be operational. **Note:** Should the removal of material accumulation from an operating conveyor become frequent, consider installing an operator work station.
Conveyor parts cleaning or maintenance (drums, rollers, chassis, etc.)	Lockout procedures apply. Operation authorized if housekeeping can be done: > With an automated jet (air or water); or > According to section 5.3 above.

*See also paragraph 3.4, Fire and Explosion Hazards.

Inspection	Visual and auditory inspection: Permissible at all times as long as the worker remains outside the danger zone. If the conveyor remains operational while the worker enters to make contact with a machine part (for example, to measure vibrations), the point where the measurements are taken must be protected by a guard. If a conveyor must remain operational while a guard is removed, apply measures in section 5.3. Lockout for all other cases (for example, mechanical free play measurements).
Unclogging, unjamming*	Lockout procedures apply. Apply measures in section 5.3 should the conveyor need to be operational.
Maintenance activities not covered above	Lockout procedures apply at all times.

* Unclogging may create new specific hazards, which must be analyzed before starting work (hazard of falling in the hopper, etc.).

6 Operator and Maintenance Crew Training

All operators and maintenance workers, who work on or in proximity to conveyors, must be informed of the hazards they may encounter, and receive training in established preventative measures and work procedures. All safety-related procedures and instructions must be documented.

6.1 Operator Training

Only trained and authorized persons must be allowed to start up, operate and interrupt the normal operation of a conveyor. Among other things, instruct operators in the following:

- Conveyor start-up
- Normal shut-down and emergency stop devices
- Required checks before starting up a conveyor after an emergency shut-down or accidental stoppage
- Proper loading procedures to avoid conveyor overload

6.2 Maintenance Crew Training

Assign only knowledgeable and trained workers possessing the necessary technical expertise to maintain conveyors. Assigned workers must be informed of the conditions under which the various maintenance tasks are to be completed. Among other training, they must be trained in lockout procedures.

When the removal of a guard or deterrent device is scheduled, the assigned maintenance crew must receive detailed instructions related to their tasks, including procedures for installing or repositioning guards or deterrent devices. Supervisors and workers must check that guards and deterrent devices are back in place when maintenance tasks are completed.